TOTAL ENGINEERING SERVICES TEAM, INC.

RTU / SCADA SYSTEMS

TYPE 24 RTU

SYSTEM REFERENCE

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1 - INTRODUCTION

The Type 24 RTU is a DTMF (Touch Tone) operated remote control system designed for low power, pulsed output operation. The unit is designed to receive touch tone signals over a half (one directional) duplex radio link and energize individual outputs for short periods (0.1 to 3 minutes). If a constantly energized output is needed (as in a Hurricane Timer), a separate latching relay can be provided. Up to 96 output channels can be supported by an Type 24 RTU. These systems are packaged for each specific application and are suitable for marine environments. Such applications include well control, platform ESD, and equipment control. Power is normally provided by a battery which is charged by a small solar panel.

2 - RTU HARDWARE DESIGN

2.1 - BASIC COMPONENTS

The standard Type 24 RTU is packaged in a single enclosure consisting of the following components:

1. Micro-Mint 80C52 CPU Board with serial and parallel port.
2. Micro-Mint 4 or 8 slot card cage.
3. TEST Inc. TYPE 2000 Control board with DC/DC converter.
4. TEST Inc. TYPE PIA-1 parallel interface card.
5. TEST Inc. MIO-1 termination boards.
6. Radio Receiver.
7. NEMA 4X Fiberglass enclosure, 24" x 24" x 8"

The hardware components used to develop this system include one Micromint computer board as well as several boards created by Test, Inc.. A summary of the hardware components is provided in a later section.

2.1 - SYSTEM HARDWARE

The receiver portion of the system consists of a tone decoder circuit, a processor board, Parallel Interface Adapter (PIA) board(s), and field wire termination boards. All boards except for the processor board are made by TEST. Up to 96 outputs can be activated on the standard unit. The timing periods can overlap if multiple outputs are activated at the same time. Therefore, it is possible to activate one output for 60 seconds, then another for 10 seconds. Each output will be separately timed for the specified period.

The special tone detection circuit provides a power down mode where power is removed from most of the circuitry during periods of inactivity. The radio receiver and tone detector are always kept active and will respond to detection of a star (*) code by powering the remainder of the devices.

The CPU board provides the tone evaluation and output timing logic for all of the outputs. Each unit is programmed with a unique address so that up to 10 units can be on the same radio frequency (expandable up to 99). The unit will receive and process all tone sequences, but it will only activate those sequences containing it's address number.

Each PIA board provides an interface between the termination boards and the processor board. Each termination board provides 8 output channels and uses industry standard output modules that can activate low voltage DC or higher voltage (120VAC) outputs. Each output is provided with an individual fuse/switch on the terminal strip for easy maintenance and output isolation. If required, several boards can be used to increase the number of outputs up to 96 per location.

Power for the unit is normally derived from a small "gel-cell" type battery recharged by a solar panel or small AC powered charger. The current draw during idle periods is less than 50ma, and the battery can power the unit for approximately a week without charging. During active periods, the unit draws approximately 750ma. The output load (solenoid or relay) must be added to this power requirement.

The transmitter portion of the system normally consists of a portable DTMF (Touch Tone) generator. This small device has a keypad similar to a telephone and generates the tones into the normal radio microphone. To avoid accidental operation, the receiver requires accurate touch tone signals. The built-in tone generator of many hand-held radios is often not close enough. Therefore, it may be necessary to use the separate tone generator even if there is one built-in to the radio. This is all the equipment that is necessary to operate the unit, and more than one radio can be used in the same system.

3 - RTU COMPONENTS

3.1 MICROMINT BCC52 COMPUTER/CONTROLLER

This board contains the 80C52-BASIC microprocessor, 32K bytes of EPROM, 8K bytes of RAM, a serial port, and an 8255 PIA chip which provides three 8 bit software configurable parallel ports. The program is stored in two 2864A EPROMs. The first program ROM must be inserted in U1 and the second in U3 of this board. The 8K RAM chip is located in U17. The serial port (J1) is not used in normal operation of the Type 24 RTU, but has some diagnostic functions. The 26 pin parallel I/O port is connected to the TEST, INC. 2000 Control Board. This port is used to read the DIP switch settings and audio signals from the 2000 Control Board. This port is also used by the software to instruct the 2000 Control Board to power down.

Although the CPU card contains a 80C52 processor containing a built-in BASIC interpreter, the TEST software uses the chip as if it were a plain 8031 and runs an optimized compiled program. The jumper settings for the Micromint BCC52 computer board are as follows:

JUMPER	SELECTION	PURPOSE
JP1	2764	Specify Type of EPROM
JP2	C000	8255 PIA Base Address
JP3	800	8255 PIA Offset Address
JP4	6000H	U12 Base Address
JP5	DATA/PROG	Specify U1, U3 & U8 as Program Areas
JP6	AS JP5	Specify U12 as a Program Area
JP7	RAM	Enable RAM in U17
JP8	AS RAM	Specify RAM in U17
JP9	Jumpered	Emulate 8031 Processor

3.2 TEST INC. PIA BOARD

This board is used as an interface between the Micromint BCC52 computer board and the TEST, Inc. MIO-1 Termination boards. This board plugs directly into the system bus and is connected to the MIO-1 boards via a ribbon cable and a DB37 connector. This connector conforms to the standard pinout used on other TEST Inc. RTU systems as well as the industry standard MetraByte parallel connection. Each PIA board can contain either 1 or 2 PIA chips and their corresponding DB37 connectors.

Each PIA chip has 24 I/O lines which are divided into three ports, A, B, and C. Each 8 bit port is configured at run-time for output and is used to access a single MIO-1 board consisting of 8 output channels. At 24 bit-channels per PIA chip and 2 PIA chips per board, there is a maximum of 48 output channels per PIA card. If more than 48 channels are needed, an additional PIA board can be used. All MIO-1 Field Termination boards associated with a single PIA chip are connected in parallel by a single ribbon cable for that chip.

There are two jumpers on each PIA board. The first one, labeled "C-E", is always set to "E" to specify that the base address of all PIA boards is E000H. The second jumper, labeled "76543210", is used to determine the offset for each PIA chip. The first PIA chip of every PIA board is socketed in U6. If a second PIA chip is present, it will be in U5. To set the offset for the first PIA chip use the pins closest to the jumper label. Use the pins on the side of the jumper without the label to set the offset for the second PIA chip. Not that both chips cannot share the same address, and that the Type 24 control program assumes that all ports are in sequence starting at address E000H.

Each PIA chip must also be offset from any previous PIA chip by 0400H. The labels "0", "1", "2", and so on represent offsets of 0000H, 0400H, 0800H, and so on. The first PIA chip of the first PIA board should always have a jumper set on the jumper labeled "0". This will give the first PIA chip an actual address of E000H. The second PIA chip (if installed) will require the jumper labeled "1" to be jumpered. If a second PIA board is used, the jumpers labeled "2" and "3" must be set for the first and second PIA chips respectively.

3.3 TEST INC. 2000 CONTROL BOARD

The Type 2000 control board is used in both the Type 2000 and Type 24 RTU systems. This board is manufactured by TEST Inc. and is responsible for waking up the BCC52 bus and the status outputs. It contains a DIP switch that is used to determine the RTU ID and 5 LEDs that can be used to monitor the audio signals. The configuration of the board is slightly different than when used in a Type 2000 RTU, which normally uses serial I/O and deletes the touch tone operations.

On the 2000 Control board, only the Power-up One-shot circuit is continuously powered. This circuitry monitors the audio terminal (terminal 20) on the 2000 Control board for audio signals received by the radio receiver. Upon detection of a star (*) code, the Power-up One-shot circuit is responsible for waking up the BCC52 bus and the remainder of the 2000 board. Refer to the section on POWER SUPPLIES for more information about the power supplies contained on this board and how they work.

Once a power cycle is started, the control board begins timing the entire session. Normally, the CPU turns off the system power when audio activity has stopped for at least 45 seconds and all outputs have cleared. If the CPU fails to turn off the system, the built-in timer will power down in a few minutes. This will prevent a system from remaining powered up indefinitely. The time period can be set with a jumper on the control board to set the overall maximum time that the unit will be powered.

The 5 LEDs on the board indicate the outputs of the tone detector circuit. Four of the LEDs represent the binary pattern of the tone currently being detected. The fifth LED is a "strobe" signal indicating that a valid DTMF (touch tone) tone pair is being received. These indicators are used to set up and troubleshoot the unit.

When a tone is being properly decoded, the strobe LED will be steadily on. The remaining 4 LEDs will be either off or on depending on the particular tone being received. The unit ignores any signals that occur without a valid strobe signal, so the strobe LED can be used to verify proper reception of any tone. The correct tone can be verified by matching the 4 LEDs with the following table:

CODE	D3	D2	D1	D0
0	On	—	On	—
1	—	—	—	On
2	—	—	On	—
3	—	—	On	On
4	—	On	—	—
5	—	On	—	On
6	—	On	On	—
7	—	On	On	On
8	On	—	—	—
9	On	—	—	On
*	On	—	On	On
#	On	On	—	—

Note that the pattern formed by the LEDs is simply a binary sequence from 1 to 12. Per standard Bell Touch Tone standards, the zero is represented as 10 decimal rather than 0 decimal so that at least one bit is on for every number being decoded. The star and pound patterns are arbitrary but are the same ones used in telephone systems around the world. The additional touch tone codes, commonly referred to as A, B, C, and D, are not used by the Type 24 system.

3.4 2000 CONTROL BOARD SETUP

This board contains a DIP switch labeled SW1 which is used to define the RTU ID. When setting the DIP switch, each switch can be set to either "On" or "Off". Setting a switch to "ON" represents a logical "1", while setting it to "OFF" represents a logical "0". By using binary notation, where a pattern of 0's and 1's are used to represent a unique number, a group of switches can be used to represent a single number other than 0 and 1. For example, a group of 4 switches is used to determine the RTU ID. These switches are illustrated in the following diagram:

SW1

1–4	RTU ID
5–8	Not used by the Type 24

The way that binary notation works is that each bit in a bit pattern represents a unique number when it is set to 1. If the bit is set to 0 it simply represents a 0. When set, the lowermost bit represents a 1 and each higher bit represents twice as much as the previous bit. For example, consider the following values assumed by each bit of a 4 bit pattern when set to 1:

BIT	VALUE
1	1
2	2
3	4
4	8

The number represented by these 4 bits is determined by adding up the values of all bits that are set to 1. For example, if bits 1 and 4 are set and bits 2 and 3 are not, the value represented by the 4 bit pattern would be 9 (1 + 8). For more examples, the following list shows several numbers and the bit patterns used to represent those numbers:

```
8  4  2  1        <—— Digital Value
4  3  2  1        <—— Bit Locations
0  0  0  0   =  0
0  0  0  1   =  1
0  0  1  0   =  2
0  0  1  1   =  3
0  1  0  0   =  4
0  1  0  1   =  5
|  |  |  |      |
1  1  1  0   =  14
1  1  1  1   =  15
```

By using 4 switches, it is possible to define an RTU ID in the range 0 - 15. However, since only one digit from a single touch tone is used to identify a particular RTU, the RTU ID for an Type 24 RTU must be in the range 0 - 9.

NOTE: It is possible to access more than ten Type 24 RTUs using the same radio frequency. To do this, a different tone sequence must be used where two audio tones are used to identify an RTU. Contact TEST for information on this expanded code sequence software.

There are 5 jumpers that need to be set on the Type 2000 board. These jumper settings are as follows:

J1 - Selects which type signal powers up the system on call-in.
- DTMF - When using touch tone signals (use for Type 24)
- CD - When using phone/radio communications
  (Phones use Brown wire - RI - to pin 21)
  (Radios use Gray wire - CD - to pin 21)
- DRY - When using external dry contact

J2 - Board Address (Set to 0)

J3 - Sets how long the control board will remain powered up on call-in. Although the software is responsible for powering down the system, this hardware feature is used as a backup mechanism to power down the system. Once powered up, the system will not remain powered up any longer than this setting allows.
NOTE: This may limit the maximum time for an output.

- A - 5 minutes
- B - 2 minutes
- S - Short to make control board time out instantly

J4 - Remove to disable software controlled power off feature.

J5 - Turns 2000 Control board on continuously when jumper is installed.

3.5 *TEST INC. MIO-1 TERMINATION CARD*

This card is used as an interface between the TEST INC. PIA board and the physical output devices being controlled by the unit. Each MIO-1 card consist of 8 output channels and is connected to a PIA board via a ribbon cable and a DB37 connector. Since each connection made to a PIA board can access up to 24 output channels, up to 3 MIO-1 cards can be connected to a PIA board in parallel by a single ribbon cable.

The address of each MIO-1 board connected by the parallel ribbon cable is determined by placing a single 74HC245 buffer chip in one of the three available sockets (A, B or C). To represent output channels 1-8, a chip is placed in socket A. Socket B is used to represent channels 9-16 and socket C is used for channels 17-24. If a system contains more than 24 output channels, additional MIO-1 cards can be used with additional connections to a PIA board. Sockets A, B and C on the additional MIO-1 cards would be used to represent the next channels in sequence.

On the MIO-1 Termination card is a jumper which is used to determine whether the channels on that card represent inputs or outputs. To setup the card for input channels a jumper must be placed on J1. For outputs, the jumper is removed. Since the Type 24 only supports output channels, J1 should never contain a jumper.

This card uses an OPTO-22/Gordos type I/O module for each channel to provide opto-isolation between each field device and the computer. Different modules are used for input and output channels. (Output modules are red, Input modules are white). Only output modules should be used by the Type 24 RTU.

The four terminal blocks on this card provide termination points for the field devices. Each channel requires two terminal points. One terminal point (V+ IN) is used for supply voltage. The other point is connected to the field end device. Next to the terminal blocks is a fuse socket for each channel. Two amp on-board Pico fuses are used to act as short circuit protection. These can be replaced with wire jumpers if the circuit is fused adequately by other means.

Each MIO-1 card contains 8 LEDs. These are simply used to indicate the status of each channel. When an LED is on, the opto-isolator module for that point is sending control voltage to the output fuse/switch on the terminal strip.

4 - POWER SUPPLIES

4.1 *POWER SUPPLIES*

A number of regulated DC voltages are required in order for the Type 24 RTU system to operate properly. However, only a portion of the system needs to be powered up continuously. The rest of the system can remain powered down during normal operation and be switched on during periods of activity.

There are two power supplies in this system that provide continuous power. Both of these are located on the 2000 Control board. A constant regulated +9 volt supply is used to power the radio receiver. A constant regulated +5 volt supply is used to power the Power-up One-shot circuit. The Power-up One-shot circuit monitors the input from the radio receiver through the audio terminal (terminal 20) on the 2000 Control board and is responsible for switching on the power supply which provides current to the rest of the system.

An integrated DC to DC power supply is used to power the BCC52 bus and the remainder of the 2000 board. This switched power supply, which is located on the 2000 Control board, accepts 9.5 - 16 VDC and produces a regulated +5, +12, -12 power supply. The DC/DC converter is only powered during the wake-up cycle of the 2000 control board, so power usage is kept to a minimum.

All power supplies in this system receive power from a raw 12 VDC source. This source usually comes from storage batteries which are often charged by solar panels.

4.2 POWER CONTROL JUMPERS

A momentary toggle switch located on the 2000 Control board can be used to manually power up the system. After 45 seconds of waiting for a command and not receiving one, the system will attempt to power down. Although the software is responsible for powering down the system, a hardware backup mechanism exists that will power down the system if the software fails. Jumper J3 on the 2000 Control board is used to control the maximum amount of time that the system will remain powered up.

During initial setup and calibration, it is often desirable to have the system remain powered. Jumper J5 on the TYPE 2000 control board can be installed to constantly power the entire system. This jumper must be removed to allow the power-down circuitry to operate properly.

5 - TYPE 24 RTU OPERATION

5.1 POWER UP/DOWN SEQUENCE

As noted above, only a small portion of the Type 24 RTU system is powered up at all times. The rest of the system remains powered down during normal operation and is switched on when a star (*) tone is decoded by a special hardware circuit. All other tones are then decoded by the same circuit and passed on to the CPU board for further processing. This section focuses on what happens from the time the entire system is powered up until it is powered down again.

When the 2000 Control board becomes fully powered up, the RTU program is automatically started. Immediately, all status I/O ports on the TEST Inc. PIA cards are programmed as output ports. All output ports on the PIA card are programmed as output ports and immediately written to prevent any outputs from coming on.

The 8255 PIA chip on the BCC52 is programmed to configure ports A and B as output ports, and port C as an input port. Port A is used to select an address and write to the TEST Inc. 2000 Control board and Port C is used to read from the selected address.

DIP switch SW1 is then read from the TEST Inc. 2000 Control board to get the RTU ID.

At this point, all timing periods for all outputs are cleared to start from scratch. An interrupt is started to decrement any active outputs once per second and a 45 second timer is started to monitor the input signals. This entire startup procedure happens almost instantly, and the Type 24 RTU is then ready to receive commands in the form of tone sequences.

The entire system will remain powered up until one of two things happens. Normally, the system will remain powered up until a period of 45 seconds has elapsed without receiving a star (*) tone. At that time, the RTU program will begin its power down process. Before attempting to power down the switched power supplies, the program will check to see if any output channels are still activated. If not, the system will immediately power itself down. Otherwise, the system will wait until all output channels have timed out before powering down.

The second way that the system can be powered down is through the use of a hardware feature present on the 2000 Control board. This feature is provided as a hardware backup mechanism to power down the system. Once powered up, an electronic timer is activated which controls the maximum amount of time the system is allowed to remain powered up. However, each time a star (*) tone is decoded this hardware timer is reset. When the hardware timer has expired and the power down process is initiated, the system is immediately powered down without checking for any active outputs. The setting of the hardware timer is determined by jumper J3 on the 2000 Control board.

One last note worth mentioning is that the power down cycle provides a one-shot pulse output that can be used to cycle the power of devices external to the control board. This output is provided at the terminal strip for use within the RTU or for an external device that may need a periodic reset signal.

5.2 RADIO RECEPTION SETUP

The Type 24 requires clear audio from the radio receiver in order to properly process the tones. If there is noise, speech, or other interference on the channel, the unit will detect improper tones and will not activate. This is not uncommon in remote and offshore locations, so it may be necessary to enter the code sequence more than once to get the output to activate.

The type of radio used does not matter as long as the audio signal is clear. The Touch Tones used in the system fall within the frequency range of normal speech, and should be transmitted successfully with most radios. The power required for the transmitter depends on the frequency, distance, height, and surrounding obstructions. If necessary, use a directional antenna on the transmitter to boost the signal received at the system.

The Type 24 can accept a wide range of audio signal and still correctly decode the touch tone. All that is required is that the signal be clear, and that the Tones be significantly louder than any background noise. It is also necessary that all of the tones be within 10% of the same amplitude. The absolute level of the signal is not as important as the signal to noise ratio.

Although the Type 24 can accept a wide range of signal levels, it is important to get the radio's volume and squelch set to proper levels. If the transmitter is to weak (or too far away), then the receiver's squelch may not break. If this occurs, then the tone decoder will not receive any audio signal. The proper settings for the receiver's volume and squelch will depend greatly on the actual physical installation, the distance involved, and the strength of the transmitter.

Setting up the receiver involves listening to the receiver speaker while transmitting with the actual radio that will be used. It is important to use the actual transmitter and receiver because the tone carrying characteristics of one unit will vary from another. The goal is to set the receiver output to a high level without over driving the tone decoder. When listening to the receiver, it may be necessary to un-plug the cable running from the radio to the tone decoder.

1. Turn squelch off so that continuous audio is heard from the receiver. Reconnect the audio from the radio to the tone board.

2. Key the transmitter and send the star (*) touch tone about once per second.

3. Monitor the LEDs on the tone decoder and adjust the volume upward until the LEDs on the decoder board blink with the tone. The 4 LEDs have a pattern of ON OFF ON ON when the star (*) code is being properly received.

4. Continue to adjust the volume until the LEDs no longer correctly detect the tone. This indicates an over driven condition.

5. If full volume does not cause a problem, back the control down until detection ceases, and then set the control halfway between this point and full volume.

6. If a volume level was reached that caused errors in the decoder, then back the volume down a bit so that the level just below the upper end of the usable range.

7. Restore the speaker audio by un-plugging the cable to the tone board. Adjust the squelch to just beyond the point where the noise stops. Reconnect the cable to the tone board.

8. Verify operation of the unit with these settings.

5.3 TONE SEQUENCE OPERATION

The Type 24 RTU unit operates by receiving audible tones and decoding them to isolate the RTU unit, the output channel, and the time duration for the output pulse. The unit will then activate the indicated output for the specified number of seconds. Unlike many tone activated units, the Type 24 does not use a single tone for any operation. A single tone could be generated by random noise on the radio channel and would cause a false output activation.

The Type 24 tone decoding is designed to prevent false output trips through the use of dual tones and a specific tone sequence for each controlled output. The dual tones are provided by the DTMF touch tones, which consist of 2 individual tones (frequencies) per code. These tones are standard Bell frequencies within the normal audio range of telephones and radios. Sequence detection of the separate tones is processed by the CPU board.

Each sequence of tones always begins with the star (*) code and ends with the pound (#) code. The sequence is re-started each time the * is received, so errors can be corrected by simply re-starting the sequence. All tones in the sequence must be received within 45 seconds in order to be processed.

The identification sequence consists of 5 digits entered between the leading * and the ending # code. Thus, there are a total of 7 keys required to activate each output point. The 5 digits are used to identify the RTU unit (0-9), the output channel to activate (1-96), the number of seconds to pulse the channel, and a "check" number.

Most of the timing codes are based on a number of 10 second periods. For example, the code 3 will provide 30 seconds of timing. Some of the higher numbers do not follow this rule so that extended periods can be commanded. The number of seconds to pulse an output channel is determined by the value of the 4th digit and is as follows:

Digit	Secs to Pulse
0	0 (cancel timing)
1	10
2	20
3	30
4	40
5	50
6	60
7	90 (special)
8	120 (special)
9	360 (special)

The code sequence uses a "checksum" feature to verify that the preceding 4 digits were received properly. The check is generated from the least significant digit of the sum of preceding 4 numbers. For example, the tone sequence to pulse channel 3 of RTU number 1 for 20 seconds is <u>* 10326 #</u>. The check number, 6, is derived as follows:

RTU Number	1
First digit of channel	+ 0
Second digit of channel	+ 3
Code for pulse time	+ 2
Check Number	6

The check number is chopped to a single digit, so a check total of 24 would be entered as just 4.

Improper tone reception could be caused by radio noise, operator error, or equipment problems. In addition to preventing stray tones from activating the unit, the check number will further insure that the operator correctly entered the desired sequence. It also insures that the unit received the tones properly.

5.3 TYPICAL TONE SEQUENCES

The tone sequences for each particular output activation requires identification of three components: the RTU number, output channel number, and the time period. In most instances, the required time duration of each output will be the same for each use of the channel, so it is possible to compile a list of the specific tone sequence for each point. These code sequences can also be placed in a small "autodialer" unit that can be held to the radio mike. This allows for automatic activation of selected outputs with only a few key presses. This section will provide examples of code sequences to assist in compiling a list for any location. REMEMBER THAT ALL SEQUENCES MUST ALSO START WITH STAR (*) AND END WITH POUND (#).

Consider a two unit installation, with each unit having 6 output channels. The possible tone sequences would be the number of units times the number of channels times the number of timing periods. This would be 2 * 6 * 10 =120 possible sequences, which is quite a lot to write down or try to remember. However, it is very likely that each output will only require a single timing period, although each output may have a different timing requirement. The list can be shortened from the possible 120 down to 12 because only a single period is needed for each of the outputs. A typical list may be as follows:

		RTU 1	RTU 2
1	Compressor Start	10124	20125
2	Compressor Stop	10214	20215
3	Well 1 Open	10360	20361
4	Well 1 Close	10449	20440
5	Well 2 Open	10562	20563
6	Well 2 Close	10641	20642

Note that in this example both RTUs were assumed to have the same point descriptions for each of the 6 points. This is for example purposes only, as each point can be used for any purpose. The point here is to show that the unique code sequence for each point can be easily calculated and written down for easy reference. These codes can also be programed into the autodialer device so that any point can be referenced with one or two keypresses.

The breakdown of the code sequence for the sixth point on RTU number 2 is as follows:

RTU Number	2	
Point Number	06	
Timing Period	4	(40 seconds)
Checksum	2	(2+ 06 + 4 = 12, use last digit only)

Therefore, the total sequence would be 20642 would be required to activate the sixth point on RTU 2 for forty seconds.

——————— End of TYPE 24 Document ———————

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